The bottom panel of Table 3 is the per-line loop investment per foot for BCPM and BCM2. This is obtained by controlling loop investment per line in the top panel for loop length shown in the middle panel of Table 3. Per-line investment per foot thus controls investment for the effects of differences in both line counts and average loop length between the two models. Differences in per-line investment per foot between the two models provides an indication of the overall magnitude of loop plant input price changes between BCPM and BCM2. This is an approximation of loop plant input price change since the difference in cost per foot may also reflect changes in quantity and/or quality due to, for example, changes in engineering parameters between the models.

On average, per-line loop investment per foot declined by 2 percent over the five states. The changes range from a 33 percent increase in Arkansas to a 12 percent decline in California. Therefore, on average, the increase in loop investment in BCPM is primarily due to an increase in loop length.

In addition to differences in per line investment between the two versions of the model, BCPM translates investments into annual expenses at a different rate than BCM2. This translation is based on the cost of money, depreciation, taxes, direct and indirect expenses, and overhead loadings. BCPM developed its annual cost factors with a more detailed analysis of asset categories.[11] In addition,

[11] We observed that while BCPM has a default weighted average cost of capital of 11.39%, the model actually uses a 7.8% cost of debt as a discount factor in calculating its annual cost factor. The model developers stated that they view this as a more conservative discount factor relative to the 11.39% weighted average cost of capital. This partly explains why the implicit annual cost factor for BCPM is lower than that of BCM2 as noted in Table 4.

information on forward-looking expenses and overheads was obtained from a survey of LECs instead of being based on historical ARMIS data. Moreover, these expenses and overhead loadings were developed on a per-line basis in BCPM instead of being based on a ratio of historical expenses to investments.[12]

Table 4 develops implicit annual cost factors for the BCPM and BCM2 by dividing the annual cost per line for each model (determined by multiplying the monthly figures from Table 1 by 12) by respective total investment per line from Table 2.

Table 4
Implicit Annual Cost Factors—BCPM and BCM2

	AR	CA	TX	UT	WA	Wtd Avg
BCPM	25.4%	33.5%	29.3%	29.2%	29.6%	31.0%
BCM2	29.8%	36.1%	33.0%	32.4%	33.2%	34.2%
% change	-15%	-7%	-11%	-10%	-11%	-10%

Table 4 shows that, on average over the five states, the implicit annual cost factor in BCPM is 10 percent lower than BCM2's factor. Thus, investments are converted to annual costs at a lower rate in BCPM.

B. Sources of Change in HM3.1 Results Relative to HM2.2.2

The most obvious reason for the change in results between HM3.1 and HM2.2.2 is the inclusion of non-Bell territories in HM3.1. As indicated in Table 5, an average of 55 percent of the difference between HM3.1 and HM2.2.2 results is accounted for by the inclusion of non-Bell territory in HM3.1. The proportion

[12] See "Benchmark Cost Proxy Model Methodology," pp. 9-10, 26-28, and 48-49. As noted in fn 5 above, while this is appropriate for estimating costs per line for universal service purposes, the per-line approach could not be used to attribute expenses to unbundled network elements.

ranges from 32 percent of the difference in California to 95 percent in Utah.

Table 5
Percent of Monthly Difference Between HM3.1 and HM2.2.2
Accounted for by Inclusion of Non-Bell Territory

	AR	CA	TX	UT	WA	Wtd Avg
1. HM3.1 Overall	$32.75	$16.65	$22.08	$24.55	$20.86	$19.35
2. HM3.1 Bell Only	$25.27	$16.09	$18.79	$20.65	$18.32	$17.50
3. Difference: 1-2	$7.48	$0.56	$3.29	$3.90	$2.54	$1.85
4. Difference: HM3.1-HM2.2.2	$11.16	$1.76	$5.28	$4.12	$3.97	$3.36
3 as % of 4	67%	32%	62%	95%	64%	55%

Other sources of difference in HM3.1 results relative to HM2.2.2 results include the following changes in default assumptions between the two versions of the model:

- a decrease in input prices from HM2.2.2 to HM3.1
- change in structure sharing assumptions
- change in proportions of aerial, underground and buried cable

Table 6
Comparison of Input Values - HM3.1 and HM2.2.2

	AR	CA	TX	UT	WA	Wtd Avg
HM3.1 Default	$32.75	$16.65	$22.08	$24.55	$20.86	$19.35
HM3.1 at HM2.2.2 Input Values	$36.17	$17.82	$23.36	$28.36	$22.49	$20.74
% change	-9%	-7%	-5%	-13%	-7%	-7%

Table 6 compares the impact of these changes in HM3.1 and HM2.2.2. This comparison was accomplished by substituting HM2.2.2's input values, where possible, into HM3.1. Table 6 shows that, on average, these changes have resulted in a 7 percent decline in per-line costs across the five states for HM3.1 relative to HM2.2.2. The declines range from 5 percent in Texas to 13 percent in Utah.

Table 7 compares the investment per line for HM3.1 and HM2.2.2. The top panel of Table 7 compares HM3.1 and HM2.2.2 total investment per line. On average, investment per line increases by 7 percent in HM3.1 relative to HM2.2.2, ranging from no increase in California to 51 percent in Arkansas. The middle panel of Table 7 indicates that loop investment per line increased by 9 percent on average, ranging from 5 percent in California to 41 percent in Arkansas. The bottom panel of Table 7 shows that switching and other investment per line increased by 2 percent on average. The changes ranged from a 14 percent decrease in California to an 83 percent increase in Arkansas.

Table 7
Comparison of HM3.1 and HM2.2.2 Investments
Stated on a Per-Line Basis

	AR	CA	TX	UT	WA	Wtd Avg
HM3.1	$1,805	$840	$1,097	$1,220	$1,078	$978
					$951	
HM2.2.2	$1,193	$839	$997	$1,065		$912
% change	51%	0%	10%	15%	13%	7%

Loop Investment Per Line

	AR	CA	TX	UT	WA	Wtd Avg
HM3.1	$1,290	$657	$836	$909	$816	$751
HM2.2.2	$912	$626	$765	$805	$739	$690

Switch and Other Investment Per Line

	AR	CA	TX	UT	WA	Wtd Avg
HM3.1	$515	$183	$261	$311	$261	$227
HM2.2.2	$281	$213	$232	$260	$212	$222

Unlike the BCPM/BCM2 comparison, we were unable to analyze the change in per-foot loop costs (i.e., Table 3) because HM3.1 does not report estimates of average loop lengths.[13] However, we were able to compute implicit annual cost factors for HM3.1 and HM2.2.2 by dividing the annual cost per line for each model (determined by multiplying the monthly figures from Table 1 by 12) by the respective total investment per line from Table 7. Table 8 presents the results. On average, the implicit annual cost factor is 13 percent higher for HM3.1 than HM2.2.2.

Table 8
Implicit Annual Cost Factors - HM3.1 and HM2.2.2

	AR	CA	TX	UT	WA	Wtd Avg
HM3.1	21.8%	23.8%	24.2%	24.2%	23.2%	23.8%
HM2.2.2	21.7%	21.3%	20.2%	23.0%	21.3%	21.0%
% change	0%	12%	20%	5%	9%	13%

III. Analysis of BCPM and HM3.1

This section focuses on a comparison of the costs produces by the current versions of the models, BCPM and HM3.1. As noted in Table 1 above, the difference between the current versions is almost the same as the difference between BCM2 and HM2.2.2. HM3.1 per-line costs are 41 percent less than BCPM per-line costs. Table 9 restates the BCPM and HM3.1 monthly cost per line estimates from Table 1 on an annual basis.[14] The difference in per-line annual costs between BCPM and HM3.1 is due to differences in investment levels between the models and the rate at which these investments are converted to annual costs.

[13] The shortcomings of HM3.1 in producing loop length information are documented in Appendix B.
[14] Costs are restated on an annual basis (multiplying monthly costs by 12) to facilitate computation of the implicit annual cost factors in Table 14 below.

Table 9
Total Annual Cost Per Line

	AR	CA	TX	UT	WA	Wtd Avg
BCPM	$635.64	$345.36	$435.60	$437.04	$426.24	$391.46
HM3.1	$393.00	$199.80	$264.96	$294.60	$250.32	$232.24
HM3.1/ BCPM	-38%	-42%	-39%	-33%	-41%	-41%

As we detail below, on average, HM3.1 investment per line is 23 percent lower than BCPM investment per line. We find that differences in switch investment and structure sharing assumptions are major contributors to the difference in investment levels between the models. Together, these two factors account for an average of 34 percent of the difference in annual costs between HM3.1 and BCPM. Although we cannot quantify their impact, differences in loop lengths and input prices also likely contribute to the difference in investment.[15]

There is also an average 23 percent difference between the models in annual cost factors--i.e., the conversion of investments to annual costs and the assignment of annual expenses and overheads. Differences in annual cost factors are due to differences in cost of money, depreciation, capital structure, taxes, expense factors and overhead allocations. Together, these factors account for an average of 51 percent of the difference in annual costs between HM3.1 and BCPM.

[15] As discussed in fn. 17 below, differences in costs for digital loop carrier systems and poles exist between the models. These differences are analyzed in Appendix C.

A. Analysis of Investment Differences Between BCPM and HM3.1

Table 10 compares total investment in each of the five states for the BCPM and HM3.1. On average, HM3.1 total investment is 14 percent less than that found in BCPM, ranging from 2 percent less in Utah to 27 percent less in Arkansas. Loop investment is 11 percent less, on average, for HM3.1 and switching investment is 23 percent less for HM3.1.

Table 10
Comparison of Investment - BCPM and HM3.1
(in thousands)

	AR	CA	TX	UT	WA	Avg
Total Investment						
BCPM	$3,231,197	$21,252,007	$15,988,001	$1,498,098	$4,788,188	$9,351,498
HM3.1	$2,369,934	$19,277,978	$13,244,632	$1,463,443	$3,782,241	$8,027,646
HM3.1/ BCPM	-27%	-9%	-17%	-2%	-21%	-14%
Total Loop Investment						
BCPM	$2,680,357	$14,945,966	$12,285,531	$1,151,740	$3,668,685	$6,946,456
HM3.1	$1,693,671	$15,085,733	$10,096,049	$1,090,217	$2,865,126	$6,166,159
Total Switching and Other Investment						
BCPM	$550,840	$6,306,042	$3,702,470	$346,358	$1,119,503	$2,405,042
HM3.1	$676,262	$4,192,245	$3,148,583	$373,226	$917,116	$1,861,486

A comparison of total investment between BCPM and HM3.1 does not produce an accurate basis for assessing differences in annual and monthly costs per line because of line estimate differences between the model.[16] A more accurate comparison is on a per-line basis. Table 11 shows that over the five states, investment per line is 23 percent less for HM3.1 than BCPM. This is the

[16] Differences in line estimates between the models is documented in Section IV below.

result of the higher line estimates in HM3.1 documented in Table 18 below, combined with HM3.1's lower level of investment. Per-line total investment is consistently lower in HM3.1 across all five states. The second and third panels of Table 11 indicate that per-line loop and switching investments are significantly lower for HM3.1 than for BCPM (except for switching in Arkansas).

Table 11
Comparison of Per-Line Investment - BCPM and HM3.1

	Total Investment Per Line					
	AR	CA	TX	UT	WA	Avg
BCPM	$2,506	$1,030	$1,486	$1,497	$1,441	$1,264
HM3.1	$1,805	$840	$1,097	$1,220	$1,078	$978
HM3.1/ BCPM	-28%	-18%	-26%	-19%	-25%	-23%
	Loop Investment Per Line					
	AR	CA	TX	UT	WA	Avg
BCPM	$2,079	$725	$1,142	$1,151	$1,104	$939
HM3.1	$1,290	$657	$836	$909	$816	$751
	Switching and Other Investment Per Line					
	AR	CA	TX	UT	WA	Avg
BCPM	$427	$306	$344	$346	$337	$325
HM3.1	$515	$183	$261	$311	$261	$227

As discussed above and documented in Appendix A, the difference in switch costs between the two models can be traced to the new switch cost equation used in BCPM. Table 12 indicates that, on average, differences in switching investment account for an average of 34 percent of the difference in total investment per line between BCPM and HM3.1.

Table 12
Proportion of Difference in Total Investment Per Line Accounted for by Switch Investment: HM3.1 - BCPM**

	AR	CA	TX	UT	WA	Avg
Differences in Total Investment Per Line	$(701)	$(190)	$(389)	$(278)	$(364)	$(286)
Differences in Switch Investment Per Line	$88	$(123)	$(83)	$(35)	$(76)	$(98)
% of Difference Due to Switch Investment	-13%	65%	21%	13%	21%	34%

**Difference stated as HM3.1 - BCPM

The difference in loop investment between the two models can be accounted for by the differences between the models in factors such as input price assumptions, loop length, structure sharing and proportions of aerial, buried and underground cable. As we document in Appendix B, reliable loop length information is not available from the HM3.1 model output. Therefore, we could not perform an analysis of the impact of loop length and the difference in loop investment cost per foot as we did in the comparison of BCPM versus BCM2 loop investment in Section II. However, the two models do differ in their default structure sharing assumptions and we analyze the impact of this difference below.[17]

Table 13 estimates the impact on investment per line of equalizing the structure sharing assumption between the two models. Both models now allow user-defined structure sharing assumptions. BCPM structures investment inputs

[17] There were significant differences in costs for digital loop carrier (DLC) systems and poles between the models. Although the costing of DLCs is not directly comparable between the models, by making some standardizing assumptions on these costs, we were able to explain an average of almost 27 percent of the difference in loop investment between BCPM and HM3.1. See Appendix C for details. We also analyzed the difference in investment due to difference between the models in the proportions of aerial, underground and buried cable. However, this difference turned out to produce insignificant differences in costs between the models.

Table 13
Comparison of BCPM and HM3.1 Loop Investment Per Line with No Structure Sharing

	AR	CA	TX	UT	WA	Avg
BCPM Default	$2,079	$725	$1,142	$1,151	$1,104	$939
HM3.1 Default	$1,290	$657	$836	$909	$816	$751
BCPM 100% Structures	$2,206	$755	$1,199	$1,207	$1,159	$983
HM3.1 100% Structures	$1,581	$779	$994	$1,083	$970	$893
Differences:HM3.1 - BCPM						
Default	$(789)	$(67)	$(306)	$(243)	$(288)	$(188)
100% Structure	$(626)	$23	$(205)	$(124)	$(189)	$(90)
Loop Difference Due to Structures	$(163)	$(91)	$(101)	$(118)	$(99)	$(98)
Difference in Total Per Line Investment**	$(701)	$(190)	$(389)	$(278)	$(364)	$(286)
% of Difference Due to Structure Sharing	23%	48%	26%	43%	27%	34%

**From Table 11

are disaggregated by density zone, installation type, terrain characteristics, and placement activities. The BCPM default inputs assign at least 75 percent of all structures costs to telephony, with the exception of poles, which are assigned 50 percent to telephony. The HM3.1 assignment of structures costs disaggregates the HM2.2.2 structures inputs by density zone, but substantially retains the HM2.2.2 sharing assumptions since the default overall average percentage assigned to telephony is close to HM2.2.2's 33 percent assumption.[18] Because of the complexity of setting the amount of sharing in one model to the default values of the other, the comparison was made by setting structure sharing in both models

[18]The fraction of aerial distribution and feeder assigned to the telco has in fact dropped to 25% in the 100+ density groups, and the overall weighted average structure fraction appears close to the previous 33% assumption.

so that all costs are 100 percent the responsibility of the telephone company (i.e., no structure sharing).

Given that BCPM default structure sharing is relatively closer to 100 percent borne by the telephone company, the increase to 100 percent (no sharing) has a smaller effect on BCPM than on HM3.1. This causes the average difference in loop investment per line to fall from $188 at the default values to $90 when 100% of structures costs are borne by the telephone company. In fact, when the structures parameter is equalized between the two models, HM3.1 produces greater per-line loop investment in California.

The bottom two rows of Table 13 relate the impact of structure sharing to the difference in total investment per line between the two models. The difference in total per line investment is taken from the top panel of Table 11. Of the average difference in total investment per line of $286, 34 percent is due to difference in structure sharing assumptions between BCPM and HM3.1. The percentage of the difference due to structure sharing assumptions ranges from 23 percent in Arkansas to 48 percent in California.

In our January 9, 1997 proxy model evaluation we found differences in structure sharing assumptions to be a key source of the difference in BCM2 and HM2.2.2 results.[19] This continues to be the case in the current versions of the models. While BCPM has introduced user-adjustable sharing parameters whose default values are generally set below 100 percent, HM3.1 default values still

[19] "Economic Evaluation of Proxy Cost Models for Determining Universal Service Support."

average around 33 percent. In its analysis of proxy models, the FCC staff stated the following regarding structure sharing in the proxy models:[20]

> "We believe that the default assumptions of BCM2 (no sharing) and Hatfield 2.2.2 (equal sharing by three utilities) are both simplistic, and that further investigation is needed by model sponsors on the sharing fraction that is most appropriate for the estimation of forward-looking costs."

BCPM has, thus, been more responsive to the specifications proposed by the FCC staff regarding structure sharing than has HM3.1.

In summary, we have identified two of the primary factors that, on average, account for 68 percent of HM3.1's lower levels of per-line investment. On average, 34 percent of the difference is due to BCPM's greater switching investment and another 34 percent is due to differences in structure sharing assumptions between the models. Although we analyze the impact of DLC and pole costs in Appendix C, other important factors, such as differences in input prices and loop length cannot be quantified at this time.

B. Analysis of Annual Cost Factor Differences Between BCPM and HM3.1

There are also differences between BCPM and HM3.1 in cost of money, depreciation, taxes, direct and indirect expense factors, and overhead loadings. This is illustrated in Table 14, which divides annual costs per line (Table 9) by investment per line (Table 11) to develop implicit annual cost factors. There are two primary components to the implicit annual cost factors: an annual capital

[20] "The Use of Computer Models for Estimating Forward-Looking Economic Costs," FCC Staff Analysis, January 9, 1997, para 42.

charge factor (ACCF) comprised of the weighted average cost of capital, depreciation and tax factors--i.e., the factors that convert investments into annual costs; and estimates of the annual expenses and overhead allocations that are included in the annual cost estimates.

Table 14
Implicit Annual Cost Factor - BCPM and HM3.1

	AR	CA	TX	UT	WA	Wtd Avg
BCPM	25.4%	33.5%	29.3%	29.2%	29.6%	31.0%
HM3.1	21.8%	23.8%	24.2%	24.2%	23.2%	23.8%

Percent Difference Between Models

	AR	CA	TX	UT	WA	Wtd Avg
HM3.1/BCPM	-14%	-29%	-18%	-17%	-21%	-23%

Table 14 indicates that the annual cost factors for HM3.1 are 23 percent lower, on average, than those for BCPM. This is the result of substantially lower annual capital charge factors in HM3.1, and lower support expense and variable overhead loadings[21]

Table 15
Effect of BCPM Implicit Annual Cost Factor on HM3.1 Monthly Costs

	AR	CA	TX	UT	WA	Wtd Avg
1. HM3.1 Default	$32.75	$16.65	$22.08	$24.55	$20.86	$19.35
2. HM3.1@ BCPM ACF	$38.15	$23.46	$26.79	$29.66	$26.56	$25.24
Difference: 1-2	$(5.40)	$(6.81)	$(4.71)	$(5.11)	$(5.70)	$(5.89)

To determine the impact of the conversion of investments to annual costs on the differences in the BCPM and HM3.1 results, Table 15 starts with HM3.1 investment per line and converts it to annual costs using BCPM's implicit annual cost factor from Table 14. The first row of Table 15 shows the HM3.1's default

[21]One reason for the lower support and overhead loadings is because HM3.1 applies the factors that determine these loadings to annualized cost, rather than to investment.

monthly costs. Row 2 applies BCPM's implicit annual cost factor from Table 14 to HM3.1 investment from Table 11 to develop annual and monthly costs as if HM3.1 used the same annual cost factors as BCPM. The bottom row shows the dollar difference between the HM3.1 default estimates and those using the BCPM implicit annual cost factor. Therefore, given the levels of HM3.1 per-line investment, HM3.1 default monthly costs are lower by an average $5.89 because HM3.1's investments are converted to annual costs with HM3.1's annual cost factors as opposed to BCPM's annual cost factors.

The difference in model results due to annual cost factors can be further decomposed into differences due to capital costing and differences due to expenses and overhead loadings. The results are displayed in Table 16. The first row of Table 16 restates the difference between BCPM and HM3.1 due to annual cost factors from Table 15. The second row shows the amount of the difference that is due to capital costs (i.e., weighted average cost of capital, depreciation and taxes), and the third row is the amount of the difference due to differences in expense and overhead loadings. To determine the effect of capital costing assumptions on the two models (row 2), we set as many HM3.1 capital cost module parameters to BCPM-equivalent values as possible. The parameter changes are listed in Table D.1 of Appendix D.

Table 16
Difference Between BCPM and HM3.1 Due to Annual Cost Factor

	AR	CA	TX	UT	WA	Wtd Avg
Difference Due to ACF	$(5.40)	$(6.81)	$(4.71)	$(5.11)	$(5.70)	$(5.89)
<u>Dollar Differences</u>						
Due to Depr and Cost of Capital	$(5.80)	$(2.78)	$(3.79)	$(4.16)	$(3.54)	$(3.28)
Due to Expenses and Overheads	$0.40	$(4.03)	$(0.92)	$(0.95)	$(2.16)	$(2.61)
<u>Percent of Difference</u>						
Due to Depr and Cost of Capital	107%	41%	80%	81%	62%	56%
Due to Expenses and Overheads	-7%	59%	20%	19%	38%	44%

Table 16 shows that the annual capital charge factors account for an average of $3.28 of the $5.89 difference due to annual cost factors (56 percent), with the amount highly variable across states. The amount of the difference accounted for by capital cost factors ranges from 107 percent of the difference in Arkansas to 41 percent of the difference in California. Annual expense and overhead loadings account for an average of $2.61, or 44 percent, of the difference due to annual cost factors. This ranges from -7 percent in Arkansas to 59 percent in California.

The results of Tables 14, 15, and 16 indicate the key role of cost of money, depreciation, capital structure, expenses and overhead loadings in determining model results and the need for stringent validation of these factors. Annual cost factor differences account for an average 51 percent of the total difference in annual costs between BCPM and HM3.1 across the five states. Of this amount, differences in the annual capital charge factors account for 28 percent of the difference, and differences in annual expenses and overhead loadings account for

22 percent of the difference, on average. These proportions are highly variable across the states.

Finally, we note that HM3.1 still employs an arbitrary reduction in expense factors to reflect "forward-looking" expenses and overheads. As we have discussed in our February 9 paper responding to the FCC staff's analysis of proxy models,[22] our productivity studies, as well as those of others, have shown that the telephone industry has consistently surpassed most other industries in its rate of productivity growth.[23] If any industry represents a model of dynamic efficiency, it would be the telephone industry. Therefore, the costs that are expected to be incurred by incumbent providers would provide a good Benchmark to assess the forward-looking economic costs for telecommunications providers. With its survey of forward-looking LEC expenses, BCPM has come closer to this standard.

C. Summary

Table 9 shows that average annual costs per line are 41 percent less for HM3.1. This is due to HM3.1's lower investment per line and lower annual cost

[22] "Appropriate Standards for Cost Models and Methodologies," Christensen Associates, February 13, 1997. Filed with Comments of the United States Telephone Association, CCB/CPD Docket 97-2, February 18, 1997, p. 10.

[23] Most productivity studies of the telephone industry have focused either on the Bell System (pre-1984), or Bell Operating Companies and other Tier 1 LECs (post-1984). For example, see Laurits R. Christensen, Philip E. Schoech, and Mark E. Meitzen, "Productivity of the Local Operating Telephone Companies Subject to Price Cap Regulation," Christensen Associates, May 3, 1994; ________ "Total Factor Productivity Methods for Local Exchange Carrier Price Cap Plans," December 18, 1995. A review of other telephone industry TFP studies can be found in Prepared Testimony of Laurits R. Christensen, Public Utilities Commission of the State of California Investigation No. 95-05-047, September 8, 1995.

factors. Table 17 summarizes the differences we have been able to explain between the two models.

Table 17
Percent of HM3.1 - BCPM Difference Explained

	AR	CA	TX	UT	WA	Wtd Avg
Percent Explained By:						
Investment						
Switching	-8%	25%	13%	7%	11%	17%
Structures Sharing	15%	19%	16%	22%	15%	17%
Investment Subtotal	*7%*	*44%*	*29%*	*29%*	*26%*	*34%*
Annual Cost Factors						
ACCF	36%	25%	32%	39%	29%	28%
Expenses and Overheads	-2%	36%	8%	9%	17%	22%
ACF Subtotal	*34%*	*61%*	*40%*	*48%*	*46%*	*51%*
Total Explained	**41%**	**105%**	**69%**	**77%**	**72%**	**85%**

Table 17 shows that we were able to explain an average of 85 percent of the difference in BCPM and HM3.1 per-line costs with the four factors analyzed in this section, ranging from 41 percent in Arkansas to over 100 percent of the difference in California. The investment factors--differences in switching investment per line and differences in structure sharing assumptions--explain an average of 34 percent of the difference in per-line costs between the two models. Other sources of difference in per-line investment between the models we were not able to quantify include differences in loop lengths and differences in input prices.

The difference in model results due to annual cost factors can be decomposed into differences in the conversion of investments into annual costs (the annual capital charge factors) and differences in estimates of annual expenses and overhead loadings. These factors account for an average of 51 percent of the difference in per-line costs between the two models.

IV. Differences in Line and Household Estimates

There are differences in line and household estimates between the current versions of the model, as well as between the current versions of the models and their predecessors. These changes are documented in Tables 18 through 20 below.

Table 18
Estimated Number of Lines
(in thousands)

	AR	CA	TX	UT	WA	Average
Benchmark						
BCPM	1,289	20,624	10,759	1,000	3,322	7,399
BCM2	1,418	20,252	10,826	905	3,294	7,339
% change	-9%	2%	-1%	11%	1%	1%
Hatfield						
HM3.1	1,313	22,950	12,076	1,200	3,510	8,210
HM2.2.2*	977	18,438	9.486	1,152	2,469	6,504
% change	34%	24%	27%	4%	42%	26%

Hatfield/Benchmark Differences

	AR	CA	TX	UT	WA	Average
HM3.1/ BCPM	2%	11%	12%	20%	6%	11%
HM2.2.2/ BCM2	-31%	-9%	-12%	27%	-25	-11%

*Note: HM3.12.2. includes only CBGs served by RBOCs

Table 18 shows the number of lines (total of residence and business) estimated in each state for each version of the respective models. Both versions of the Benchmark model include switched and special lines. HM3.1 includes switched lines only, while HM2.2.2 includes switched and special lines. On average, over the five states, BCPM produces almost the same line estimates as did BCM2. However, this masks some significant variation by state. For example, lines in Arkansas declined by 9 percent in BCPM compared to BCM2, while lines in Utah increased by 11 percent. The reason for the state variation is that BCPM now computes its residential line multiplier at the state level as opposed to the nationwide residential line multiplier used in BCM2. This allows BCPM to better reflect state-specific penetration rates. For example, according to the BCPM residential line table, Arkansas has below-average first and second line penetration, while Utah has above-average first and second line penetration. There are two reasons for the difference in line estimates between HM3.1 and HM2.2.2. Obviously, the inclusion of non-Bell territories in HM3.1 causes an increase relative to HM2.2.2. However, the Bell line estimate in HM3.1 is lower than the Bell line estimate in HM2.2.2 because HM3.1 only includes switched access lines, while HM2.2.2 includes both switched and special lines.

Given the inclusion of non-Bell territories in HM3.1, the line estimates for BCPM and HM3.1 should be comparable. However, Table 18 indicates that line estimates for HM3.1 are 11 percent greater than those for BCPM over the five states we analyzed. The discrepancy in line estimates reported by each model can be traced to several different sources. First, each model uses a different source for its input data. Second, HM3.1 only controls the line estimates for companies that report to the FCC (i.e., Tier 1 companies).

The BCPM develops a statewide residential line multiplier that is applied to the number of households in each CBG to estimate the number of lines in each CBG. The residential line multiplier is calculated by dividing the statewide number of residential access lines by the statewide number of households. The source for the residence lines that goes into the multiplier is the 1995 number of USF loops reported to NECA less the estimated number of business lines. The 1995 estimated number of business lines was unavailable at the time, so the BCPM developers substituted 1994 estimates.[24]

For HM3.1, Hatfield Associates hired PNR and Associates to estimate residential line counts based on the number of households in each CBG. HM3.1 controls the model's estimated line counts to line counts for Tier 1 companies filing ARMIS reports. The model does not control line estimates for companies that do not report to ARMIS.

Therefore, statewide BCPM results should be more accurate because the totals are controlled to NECA reported line counts and HM3.1 does not control estimates for non-Tier 1 companies. For ARMIS reporting companies, the HM3.1 results should be accurate because the results are controlled to actual reported line counts. For non-reporting companies, neither model can produce a precise estimate. Even though the NECA data used by BCPM contains non-ARMIS companies, BCPM line estimates are accurate only at the state level. HM3.1 results are dependent on PNR and Associates assignments of lines to CBGs and the number of lines being assigned needs to be validated.

[24] However, if the 1994 business lines were not grown to 1995 levels, the number of residential lines may be overstated in BCPM.

Table 19
Estimated Number of Households

	AR	CA	TX	UT	WA	Average
Benchmark						
BCPM	942,872	11,033,168	6,684,245	608,219	2,089,800	4,271,661
BCM2	891,665	10,399,343	6,079,341	537,196	1,875,508	3,956,611
% change	6%	6%	10%	13%	11%	8%
Hatfield						
HM3.1	1,067,300	15,511,770	6,663,537	819,197	2,278,001	5,267,961
HM2.2.2*	574,269	8,145,099	4,903,950	568,531	1,350,151	3,108,400
% change	86%	90%	36%	44%	69%	69%

*Note: HM2.2.2 includes only CBGs served by RBOCs

Hatfield/Benchmark Differences

	AR	CA	TX	UT	WA	Average
HM3.1/ BCPM	13%	41%	0%	35%	9%	23%
HM2.2.2/ BCM2	-36	-22%	-19%	6%	-28%	-21%

Table 19 compares household estimates for the models. Given that both BCPM and HM3.1 employ a 1995 estimate of households, the numbers should be similar. However, as in the case of lines, the number of households differ significantly between the two models. On average, the HM3.1 estimate of households is 23 percent greater than BCPM estimates. In fact, it is 41 percent greater for California. The only state where the two estimates come close is Texas.

We investigated the possibility that a difference in the number of CBGs in each state was a source of discrepancy between the models. However, we found the CBG counts to be almost the same, differing by an average of only 0.1 percent between BCPM and HM3.1.[25] Given the discrepancy in household estimates and the similarity of CBG counts for the two models, this implies that the average household estimate per CBG differs widely between the two models. Given that both models have used 1995 Census estimates, it is puzzling that the household estimates differ by so much. The reason for this discrepancy remains unknown.

Table 20
Lines Per Household
(Business and Residential)

	AR	CA	TX	UT	WA	Average
Benchmark						
BCPM	1.37	1.87	1.61	1.64	1.59	1.73
BCM2	1.59	1.95	1.78	1.68	1.76	1.85
% change	-14%	-4%	-10%	-2%	-9%	-7%
Hatfield						
HM3.1	1.23	1.48	1.81	1.46	1.54	1.56
HM2.2.2*	1.70	2.26	1.93	2.03	1.83	2.09
% change	-28%	-35%	-6%	-28%	-16%	-26%

*Note: HM2.2.2 includes only CBGs served by RBOCs

Hatfield/Benchmark Differences

	AR	CA	TX	UT	WA	Average
HM3.1/ BCPM	-10%	-21%	13%	-11%	-3%	-10%
HM2.2.2/ BCM2	7%	16%	9%	20%	4%	13%

Table 20 combines the information from Tables 18 and 19 to obtain an estimate of lines per household for the models. Both BCPM and HM3.1 exhibit a

[25] Even though the count of CBGs is very close on a statewide basis, individual company estimates within a state could be affected dramatically by assignment of CBGs to particular companies. For example, GTE found that Release 3.0 of the Hatfield model overstated GTE California service area by 85 percent. See "GTE Comments," CCB/CPD Docket 97-2, February 18, 1997, p. 44.

significant decline in lines per household from the previous versions of the respective models. On average, lines per household have declined by 7 percent in BCPM relative to BCM2 and by 26 percent in HM3.1 relative to HM2.2.2.

Comparing current versions of the models, BCPM averages 1.7 lines per household, compared to 1.6 for HM3.1. In fact, for all five states, HM3.1 has a lower number of lines per household than BCPM. Thus, the difference in household estimates between BCPM and HM3.1 is relatively greater than the difference in line count, leading to a lower estimate of lines per household for HM3.1

V. Evaluation of Other Model Features

This section presents an evaluation of other features of the new releases of the two models. First, we compare estimates for Bell and non-Bell territories. Next, we assess the operation of the models.

A. Comparison of Bell and Non-Bell Estimates

One of the new features of HM3.1 relative to its predecessors is the ability to produce estimates for non-Bell territories. Table 21 compares the estimates using default input values with Bell-only and non-Bell estimates for both BCPM and HM3.1.

As expected, Table 21 shows that both models produce monthly costs that are lower for Bell-served territory than for the rest of the state. Table 21 indicates that the deviation between BCPM and HM3.1 is similar for Bell-only and non-Bell estimates, with a slightly greater gap for Bell-only estimates. On average HM3.1 monthly costs are 41 percent less for the statewide estimates, 42 percent less for the Bell-only estimates, and 39 percent less for the non-Bell estimates. Bell costs are an average of 8 percent lower than the statewide average for BCPM and 10 percent lower for HM3.1.

Table 21
Comparison of Bell and Non-Bell Estimates - BCPM and HM3.1

	AR	CA	TX	UT	WA	Avg
BCPM Default	$52.97	$28.78	$36.30	$36.42	$35.52	$32.62
BCPM Bell Only	$43.62	$28.06	$32.14	$33.47	$30.93	$30.19
BCPM Non-Bell	$70.34	$31.02	$49.89	$97.36	$45.05	$40.19
HM3.1 Default	$32.75	$16.65	$22.08	$24.55	$20.86	$19.35
HM3.1 Bell Only	$25.27	$16.09	$18.79	$20.65	$18.32	$17.50
HM3.1 Non-Bell	$47.32	$18.26	$31.30	$103.63	$ 26.22	$24.69
Default: HM3.1/BCPM	-38%	-42%	-39%	-33%	-41%	-41%
Bell: HM3.1 /BCPM	-42%	-43%	-42%	-38%	-41%	-42%
Non-Bell HM3.1/BCPM	-33%	-41%	-37%	6%	-42%	-39%

B. Assessment of Model Operation

In performing the analysis of BCPM and HM3.1, we also noted some of the operational features of the models that need improvement.

- When choosing a state and a company within a state to process, the BCPM should only show the companies that operate within the given state. Instead, the user is shown a nationwide list of telephone companies and must scroll down the list until the correct company is found.
- The Hatfield Model cannot process all companies in a state in one run.
- Both models should allow groups of companies or states to be run.

- The HM3.1 is unstable. We ran the program on several computers with hardware configurations meeting or exceeding the documented requirements and encountered frequent fatal run-time errors trying to run some of the larger states on certain machines. In contrast, we never encountered a fatal run-time error with the BCPM.
- The HM3.1 does not allow multiple scenario analysis.
- The HM3.1 gives the impression of being able to run multiple scenarios because it has a complete list of inputs in each module. However, this is deceptive because changes made to the inputs in each module have no effect when the model is run through the user interface. This is because scenario inputs are copied into the module worksheets from Microsoft Access tables when the user interface program launches the modules.
- The HM3.1 user interface has defects which prevent the user from changing the structures sharing percentages for buried distribution. If the user updates the buried distribution percentage using the interface, only the 0-5 input value is changed in the database; the other density zone inputs are unaffected. If the user calls up the dialog box to verify its input values, the other density zone entries are filled using the 0-5 value only. This provides the user with a misleading picture of the model input values.
- Some BCPM logic is contained in the control module--e.g., the code which computes USF support amounts. As a consequence, the full effect of the user inputs on the expense module can only be calculated through the user interface.
- Capital cost calculations are effectively undocumented in both models.
- HM3.1 asset lives are supposed to be adjusted for net salvage, but the net salvage factors, unadjusted economic lives, and adjustment algorithm are all outside the model and undocumented.
- State tax factors (state corporate income tax, gross receipts tax rates, etc.) should be state-specific in HM3.1, rather than national average values. They are state-specific in BCPM.
- While it is important to have user adjustable structures factors, the factors in BCPM are complicated and not easily adjusted in a comprehensive manner. This may be a detriment to proper use and understanding of the structures factors.